Automated Toll Tax Collection System Using Cloud Database

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Abstract- *The rapid growth in transportation networks has led to an increase in the demand for efficient and seamless toll collection systems. Traditional toll booths involve manual intervention, which often leads to traffic congestion, delays, and operational inefficiencies. This paper proposes an Automated Toll Tax Collection System utilizing cloud database technology to address these challenges. The system leverages an integrated approach where vehicles are identified using RFID (Radio Frequency Identification) technology, and toll payments are processed automatically through a centralized cloud-based platform. This platform allows real-time data storage, easy access, and seamless updating of toll transactions, vehicle information, and payment statuses. The cloud database ensures scalability, flexibility, and cost-effectiveness while providing advanced security measures to safeguard user data. Additionally, the system provides an intuitive user interface for vehicle owners to track payments and account details. By reducing human intervention and enhancing operational efficiency, this automated system promises to improve toll collection accuracy, reduce traffic congestion, and provide a smooth travel experience for commuters. The proposed system also offers potential for integration with other transportation infrastructure technologies, facilitating smart city initiatives.*

Keywords- Toll Booth, RFID, Arduino, IoT, Cloud Computing, WiFi Module, Firebase database etc

I. INTRODUCTION

The efficient management of toll collection on highways, bridges, and expressways has always been a significant challenge due to the complexities of manual operations and the growing demand for transportation. Traditional toll collection systems often involve manual payment methods or outdated automated mechanisms that require physical infrastructure, such as toll booths, which can lead to traffic congestion, delays, and high operational costs.

Moreover, the need for continuous monitoring, tracking, and updating of toll transactions and vehicle data is a resource-intensive process. With the advent of cloud computing and advanced technologies, there is an opportunity to revolutionize toll collection by creating an Automated Toll Tax Collection System that is efficient, scalable, and minimizes human intervention. This system leverages RFID (Radio Frequency Identification) technology for vehicle identification and integrates with a cloud database for the real-time processing and management of toll payments. By utilizing a cloud database, the system ensures seamless storage, retrieval, and updating of user data and payment transactions, while also offering enhanced flexibility and scalability. This also ensures that data is readily available for both transportation authorities and vehicle owners, providing transparency and reducing the scope for errors or fraud. The cloud-based infrastructure offers several advantages, including reduced dependency on physical hardware, real-time monitoring of toll collections, centralized data management, and the ability to easily scale as traffic volumes grow. Furthermore, it provides a platform for data analytics, which can be utilized to optimize toll rates, analyze traffic patterns, and improve infrastructure planning. In this paper, we present an overview of the automated toll tax collection system, focusing on the integration of RFID technology with cloud-based databases to streamline toll collection processes, enhance user experience, and offer more efficient management of transportation systems.

Fees at the rates specified by the rules made in support of services or benefits related to the use of transportation, permanent bridges, temporary bridges, tunnels on national highways, and sections of national highways are levied by the Central Government and are communicated to the public through the publication of an announcement in the official newspaper. These fees are intended to generate revenue for the Central Government.

For publicly funded, annuitized, and SPV projects, the government is responsible for collecting the user charge (toll) by hiring the contractors through a competitive e-bidding process. On the other hand, the concessionaire is responsible for collecting the user charge (toll) for privately funded and OMT projects (toll). Tolls in India are normally collected using an open system; the price is a flat rate that is determined by the whole distance covered by the project, which is typically sixty kilometres. When a stretch is less than

anticipated, the user fee that is based on real length is the only one that is collected. The user price for a particular fee plaza is decided by the length of the stretch of highway below that plaza, the width of the roads, the structures (bridges, tunnels, and bypasses), the applicable fee legislation, and the conditions of the concession agreement. The classification of automobiles is done so for the sake of everyone's safety on the road. The primary factors that determine how a vehicle is categorised are its dimensions, the maximum payload it can carry, the amount of wear and tear it inflicts on the pavement, and the function it is designed to do (commercial or personal). The pricing rules from 2008 stipulated that there should be a gap of sixty kilometres between any two toll plazas that were located in close proximity to one another.

II. LITERATURE REVIEW

- **Aniruddha Kumawat et.al.(2019) :** an Automated Toll Collection System using RFID used for collecting tax automatically. Radio frequency is used for identification. A vehicle will hold an RFID tag. All the basic information of the vehicle will be stored in this, along with the amount paid by the vehicle at the toll booth. Whenever a vehicle will pass the toll booth, the readers which will be placed will read the vehicle and also deduct the necessary amount of cash. The new balance would be updated after the transaction gets over. If the balance is insufficient, the net total amount I the card goes to negative. This may lead to some financial loss to the system. So negative balance can be an escape for anunauthentic vehicle.

- **Khadijah Kamarulazizi and Widad Ismail et.al. (2018):** this paper focuses on an electronic toll collection (ETC) system using radio frequency identification (RFID) technology. This method automated the system and eradicated the need and hassle of manually paying the toll.

  Data information are also easily exchanged between the vehicle and the authority that is collecting the tax, thereby enabling a more efficient toll collection by reducing traffic and eliminating possible human errors. But this was limited to the local servers, so scalability and reach upto all tolls was not possible.

- **S.Nandhini, P.Premkumar et. al. (2014):** most Electronic Toll Collection (ETC) systems around the world are implemented by DSRC (Dedicated Short Range Communication) technology. This system talks of an automated toll gate system where transaction details are sent on the mobile phone of the motorist using a GSM module. It is a revolutionary idea for a speedy toll collection and verification as well. In this paper, the frame composing and working flow of the system is described and data information is also easily exchanged between the motorists and toll authorities, thereby making it a more efficient process.

- **P. Arokianathan et. al. (2017):** he built a model of an automated toll booth with a theft detection system. The model requires the user to input the source and destination before being directed to the payment option, which is a procedure that is still time-consuming. The most important benefit, on the other hand, is that the theft detecting system that was built into this structure makes it possible to recover a stolen vehicle when it arrives at the toll plaza.

- **Sabbir Ahmed et. al. (2019):** the devised a model of a toll collection system that makes use of RFID technology. This technology helps to decrease the amount of physical work that is necessary in order to collect the toll tax. However, there was no mechanism in place to check whether or not the RFID tag that was being read was exclusively associated with the car that had just passed through the toll plaza. Therefore, this continues to be a significant drawback of the paradigm that they have suggested.

- **Chintaman Bari et. al. (2021):** It investigated the toll plaza that is now in use at the Ghoti Toll Plaza, which is located in Nashik, India. In conclusion, they said that the manual toll collecting method (MTC) was 95 percent more time consuming than the electronic toll collection system (ETC). In order to solve the issue that currently exists with human toll collecting,

- **Rajiv Israni et. al. (2019):** It developed an automated toll collection system. The method of image processing is his primary focus in terms of technology. This method is similar to OCR, which stands for optical character recognition, and it extracts the licence plate number from a car by using a camera. After the data has been extracted from the picture using image processing, it is looked up in a database to determine if it is legitimate or not registered. The amount of the toll is immediately detected, and the vehicle is permitted to go through the toll plaza if the registration number is correct.

- **Raed Abdulla et. al. (2014):** He developed an electronic toll collection system that makes use of RFID technology and the internet of things. When a car passes through the toll, the RFID tag attached to it is read, and the Internet of

Things is utilized to communicate data to the main office through the cloud. In this instance, the author suggests a new approach in which the barrier gates are opened and do not shut for the people who have proper registrations. Therefore, the passage through the toll booth takes an average of six seconds, which is a significant amount of time.

III. CHALLENGES IN EXISTING SYSTEMS

- **Existing system:-** Today, there are two types of toll collection system. Either all the vehicles have to stop at toll plaza on the highway to pay the toll tax, where one person collects the money and provides a receipt, after which barrier is opened either mechanically or electronically or the other is smart card system i.e. RFID based FASTag systems, in which FASTag is attached to the windshield of the car and when the car reaches near the toll plaza, the hardware sensors installed at the toll plaza detects the tag and specific amount is deducted from the user's card. User needs to recharge the tag with appropriate amount.
- **Drawback of existing system:-** The existing system for toll collection is time consuming and also you need to stand in queues, wait for the attendant to provide change and when the ticket is return ticket then you need to preserve the receipt. This process results in traffic jams. For RFID/FASTag systems, the user and the toll plaza needs to install RFID/FASTag readers.

IV. PROPOSED SYSTEM DESIGN

A. Radio Frequency Identification (RFID):

RFID, is used for identification and uses electromagnetic field in the process. RFID system consist of two components, RFID tag and RFID reader. The RFID tags that are available in the market electronically store information. RFID tags are of two types

a) Active RFID tags
b) Passive RFID tags.

Passive RFID tags do not have a battery of their own and extract all its powers from the radio waves of the RFID reader. Here is where an active RFID tag differs from a Passive one, because an active RFID tag has its own battery and can be detected by a reader from hundreds of metres away. RFID is one method for Automatic Identification and Data Capture. RFID reader is used to reading the tags, collecting the stored information and then communicating the result to a IoT controller or to database. Reader communicate with tag using its own antenna. This Radio Frequency Identification has found widespread use in the recent times and has been the centre of development when talking about the Internet of Things. RFID tag used for this work is as shown below in Figure.

Figure1: RFID Tag Used

B. Arduino Microprocessor

Arduino is an Open Source enterprise that aims at making this world a better place by producing single board microcontrollers and microcontroller kits that can be programmed to develop devices that are endowed with abilities to interact with objects from the non-digital world. Various microprocessors and controllers are part of different Arduino designs. The board provided has numerous Input/output pins that can be used to interface with different devices and boards. It consists of programmable circuit board and integrated development environment which is used to write the code and then feed the code to circuit board. Arduino can be coded for a designed function or a specific task. The Arduino has USB port that lets us connect it with the computer and in turn is used to upload programs on it. The language used for coding is generally C and C++ and all the embedded libraries are also available. Arduino also provides a dedicated integrated development environment (IDE) based on the Processing language project for compilation and upload of our Sketch (Program) on the board. It has 6 analogue input pins and 14 digital I/O pins.

C. Wi-Fi Module ESP 8266

Wi-Fi is the phenomenon in which computer or other devices communicate with one another. The ESP8266 is a Microcontroller unit capability. It is a low cost Wi-Fi and it comes with the TCP/IP stack fully embedded. It has a micro USB port for power, programming and debugging operations. This module is connected with Arduino kit as shown in Figure.

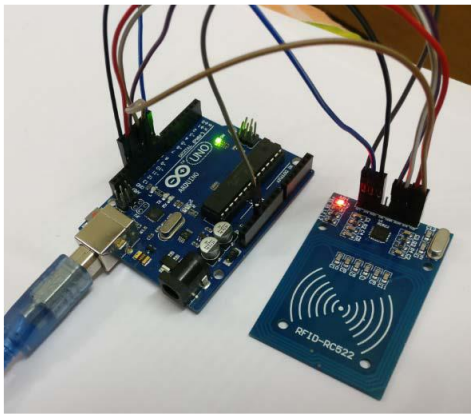

Figure 2: Arduino connected with WiFi Module for sending data to cloud database server

D. Mobile App

A mobile app is developed in this system, which can connect every user with toll database. User can see the tolls on his way and can check the balance in his wallet. As his vehicle passes from toll gate, automatic his vehicle registration number is read and payment from his wallet balance is deducted. Receipt of toll charges is generated and can be downloaded from his mobile application user login controls. Then using app user can add balance into wallet.

E. Use of Sensors

We are using Radio Frequency Identification as a means to see which vehicles are registered and which are not. RFID tags are installed on each vehicle and when the vehicles close in on the gate, the RFID reader strategically placed, does read the tag and checks on the basis of the initiation made. RFID uses Electromagnetic field in the process of Identification. The cards used in this process can either be Read-only or Read write depending upon the cost structure. The Read-only RFID tags cannot hold any data but the Read-write tags can hold up to 128B of data. The RFID cards have a unique Identification number which are used for checking whether a given vehicle is registered or not. This section holds major significance because it decides that whether the vehicle entering is valid or not and then proceeds for the pay.

F. Data Acquisitions

Every RFID tag has a unique Identification number and it is unique for all the cards. As we will recognize the vehicle by the tag/card embedded in the vehicle so at the time of vehicle's registration, it is must that every vehicle must be associated with a RFID tag. In this way, every vehicle will have a unique identity that can be easily identified by the RFID reader. The RFID reader in turn, reads all the RFID tags to fetch their unique ID numbers, and the Arduino is programmed to only accept certain RFID tags, thus allowing only the vehicles with the registered tags on them. The moment the tag comes within magnetic field of RFID reader, current is induced in it and it get energized.

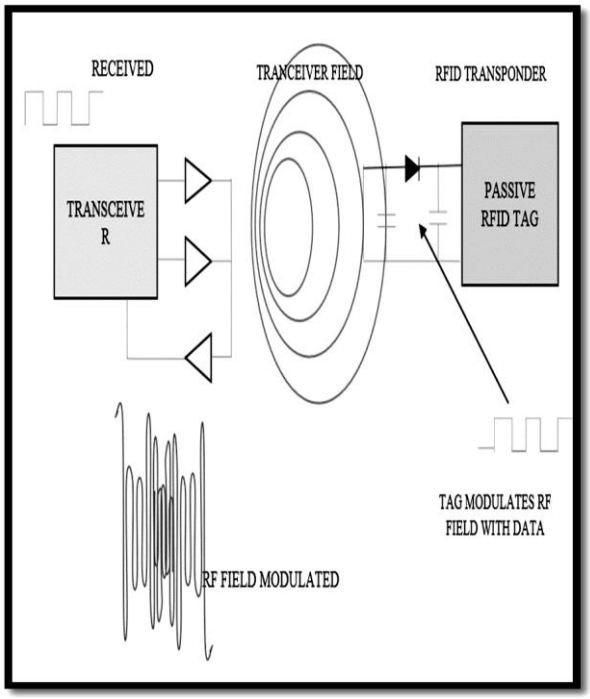

Figure 3: Valid RFID Identification framework

Thus stored information in tag is sent to reader. Then the designed system authenticates the user and allows the person to pass through the toll after deducting a fixed amount. All information of user is stored in cloud. The database containing all the details of the vehicles is set up on Firebase cloud service.

With every unique Identification number, is associated three other fields, namely, Name of the owner, Registration number of the car and the account balance for the toll payment. From here on, this data is fetched and further analysis on the data is performed.

G. Flowchart

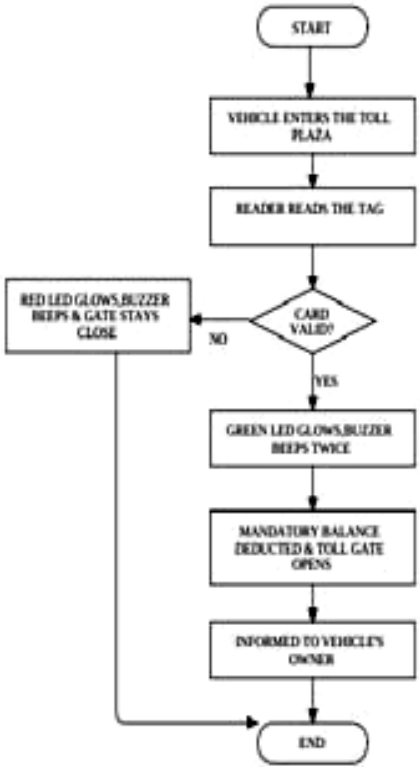

Figure 4: Working Flow Chart of Toll Automated System

The process starts as soon as the vehicle comes at toll plaza. As shown in Figure. The RFID reader present there will sense the RFID tag embedded in the vehicle. As the magnetic field will energies the tag which results the sending of stored data to RFID reader. Now the system will authenticates the card. If the card is invalid then buzzer will beep and gate stays close. If the case is valid, then green led glows and a mandatory balance will be deducted from user wallet. Thus, user can enjoy pause free ride.

H. Cloud Framework Used

The complete procedure of automating the toll gates creates data at runtime and this dynamic data needs to be stored. So, for creating a dynamic database, Firebase is used. Cloud framework used is shown in Figure. Firebase, powered by google, provides numerous services, with Dynamic Database and Backend as a service. The service provides application developers an API that allows application data to be synchronized across clients and stored on Firebase's cloud. Android, iOS, JavaScript, Java.

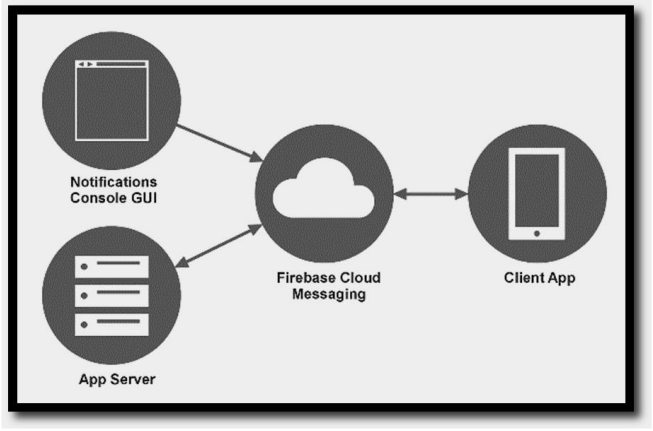

Figure 5: Firebase and Application Connectivity

In Firebase, a database is created that has the details of each of the vehicles registered and every time the RFID reader returns an identification number, the number is dynamically checked in the database and if the elements in the field array match with that of the identification number of the vehicle that is passing, then we can proceed to seeing if that particular vehicle has sufficient balance. If the balance turns out to be sufficient, a balance pay is initiated and the new balance is dynamically stored on the database. The database is maintained and is dynamically updated with the balance after each subsequent turn of passage of the vehicle. The data from the RFID reader is the only data that is used for identification of the vehicle and thus maintains the uniqueness and low error margin in the process. The process enhances the existing traditional methods in every way possible and paves way for a better future. It also offers the usage of system in all geographical areas.

V. SYSTEM IMPLEMENTATION

5.1. System Model

The illustration aforementioned gives us a clear idea of how the physical framework of the system would look like shown in Figure 6. The vehicle, upon its arrival would be sensed by the RFID reader that would read the number provided on the car, the system upon verifying the valid entities deducts the balance and updates the same on the cloud service that is in use. The complete model is based on the utilization of the Radio Frequency Identification which can sense data from a distance and thus becomes handy in such situations where we have to retrieve data from a moving object in the vicinity.

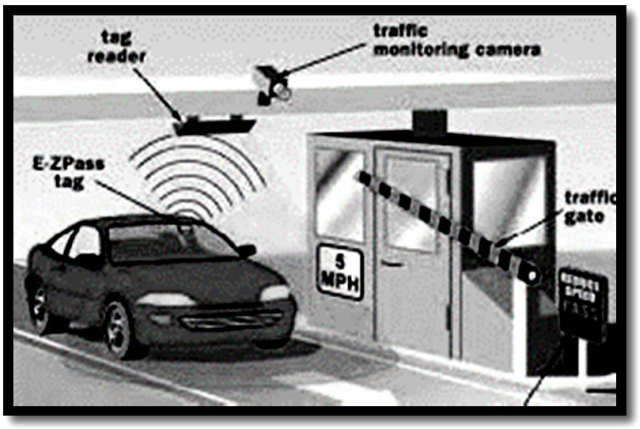

Figure 6. - Toll gate Activity Module

The vehicle and the mobile application both will hold relevance while connection with the tollgate. A fairly simple yet robust depiction of the problem hereby follows. The vehicle upon being sensed will be verified from the data that is fetched from the Cloud database by the virtue of the World Wide Web, the vehicle is then prompted into the toll booth and the amount is deducted from the application. While this happens, the new value of the balance is pushed back into the cloud database all over again.

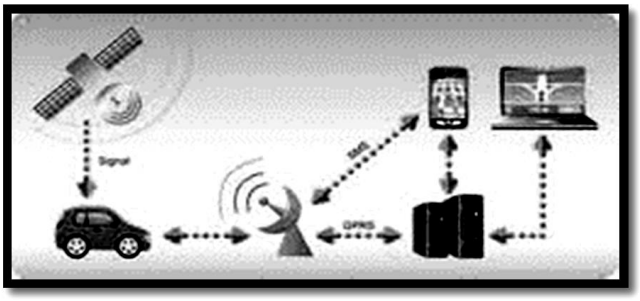

Fig 7. - Model for the System

5.2. Mobile App and its working

User can use the app for easy monitoring. Each card will be given a unique username and password. After successful login, user can see all the details related to this process involved. User can see the remaining balance in the wallet and can monitor the previous transactions. With every transaction, the new balance would be updated. In case of insufficient balance, user can add the money using e-mode by the app. The application serves its purpose good becomes it comes in as a handy piece of digitalization while we enjoy a pause free ride. The app also serves its purpose when we try to backtrack all the transactions that have been initiated at the toll gates. The application receives a push notification every time some transaction takes place. This can be helpful in cases of theft too, because we can actually track down or car on the basis of this very system. The basic model of the application is provided herein.

VI. BENEFITS OF SYSTEM

- **Reduced Traffic Congestion:-** The automated toll collection system minimizes the need for vehicles to stop at toll booths, reducing delays and congestion. This leads to smoother traffic flow, especially during peak hours, enhancing overall travel time and efficiency.
- **Improved Accuracy and Reduced Errors:-** By automating the toll collection process, the system reduces human intervention, which minimizes the possibility of manual errors in toll charges and payments. Accurate and automated data entry ensures correct billing and payment tracking for all users.
- **Real-Time Data Processing:-** With the integration of a cloud database, toll payments and vehicle data are processed and updated in real time. This allows for immediate confirmation of toll transactions and ensures up-to-date information is available for both authorities and vehicle owners at all times.
- **Scalability and Flexibility:-** The cloud-based infrastructure allows the system to easily scale as traffic volume increases or toll collection points are added. This flexibility ensures that the system can adapt to changes in transportation networks without the need for major hardware upgrades.
- **Cost Efficiency:-** A cloud database reduces the need for extensive on-site infrastructure, such as servers and storage systems. This lowers initial setup costs and ongoing maintenance expenses for toll operators. Additionally, the use of automated systems reduces labor costs associated with manual toll collection.
- **Enhanced Security:-** Cloud databases provide robust security measures, including encryption, secure access controls, and real-time monitoring, ensuring that user data and payment information are protected against fraud and unauthorized access. Cloud service providers also ensure regular backups, minimizing the risk of data loss.

VII. CONCLUSIONS

The Automated Toll Tax Collection System utilizing a cloud database presents a significant advancement in the way toll collection is managed, offering numerous benefits over traditional manual or semi-automated systems. By integrating RFID technology and cloud computing, this system ensures a seamless, efficient, and error-free toll collection process. The cloud infrastructure enhances scalability, flexibility, and security, while also reducing the operational costs associated with hardware maintenance and

manual intervention. The system's real-time data processing capabilities ensure that toll payments and vehicle information are always up-to-date, providing transparency and improved accuracy for both toll authorities and vehicle owners. Additionally, the automated nature of the system reduces traffic congestion, minimizes delays, and offers an enhanced user experience, which is crucial for the smooth functioning of modern transportation networks. Moreover, the ability to collect and analyze large volumes of data allows for better decision-making in traffic management, revenue collection, and infrastructure development. The integration with broader smart city initiatives further enhances the potential for developing sustainable and intelligent transportation systems. In conclusion, the Automated Toll Tax Collection System using cloud databases offers a robust, efficient, and future-proof solution for modern toll collection needs. It not only improves the operational efficiency and user experience but also supports long-term infrastructure planning and growth, positioning it as a key component of smart transportation systems in the future.

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